Handling and Shipping POTATOES in Bulk to Processing Plants

U. S. DEPARTMENT OF AGRICULTURE • Marketing Research Report No. 625
Agricultural Marketing Service • Transportation and Facilities Research Division

PREFACE

The study on which this report is based is part of a research project to develop more efficient work methods, equipment, and facilities for off-farm handling, sorting, cleaning, grading, sizing, and packing of fall-crop potatoes. It is part of a broad program of research by the Agricultural Marketing Service to reduce costs in the marketing of farm products.

This study was carried on under the general supervision of Joseph F. Herrick, Jr., marketing research analyst, Handling and Facilities Research Branch, Transportation and Facilities Research Division, AMS.

The following firms made their facilities available for this study: Mack Potato Company, Gust Hangsleben Potato Company, Hoffert Motor Service, Troyer Manufacturing Company, Mayo's Manufacturing Company, and Odin's Welding Shop, all of East Grand Forks, Minnesota; and Lockwood Graders, Inc., Grand Forks, North Dakota.

Alfred D. Edgar and Earl C. Yaeger, agricultural engineers, Transportation and Facilities Research Division, contributed valuable suggestions and assistance.

This report is related to an earlier one, Marketing Research Report No. 495, "Handling and Shipping Potatoes to Processing Plants in Pallet Boxes and Burlap Bags," and discusses what is generally termed "bulk" handling and shipping.

Previous publications on improved methods, equipment, and facilities for handling, packing, and storing potatoes include:

From the Marketing Information Division, Agricultural Marketing Service, U. S. Department of Agriculture, Washington 25, D. C.:

A Lightweight Conveyor for Filling Deep-Bin Potato Storages. AMS-362, February 1960.

Pressures on Walls of Potato Storage Bins. AMS-401, August 1960.

Pallet Boxes for Handling and Storing Potatoes. AMS-455, October 1961.

From the Office of Information, U. S. Department of Agriculture, Washington 25, D. C.:

Storage of Fall-Harvested Potatoes in the Northeastern Late Summer Crop Area. MRR No. 370, January 1960.

Handling Potatoes Into Red River Valley Storages--Methods and Equipment. MRR No. 471, 1961.

Handling and Shipping Potatoes to Processing Plants in Pallet Boxes and Burlap Bags. MRR No. 495, September 1961.

Shell Ventilation Systems for Potato Storages in the Fall Crop Area. MRR No. 579, January 1963.

Out of print, but may be consulted at major libraries:

White Potato Storages for New Jersey, Long Island, and Southeastern Pennsylvania. MRR No. 70, June 1954.

An Improved Elevator for Deep Bin Potato Storages. MRR No. 131, August 1956.

Flume Systems for Handling Bulk-Stored Potatoes. MRR No. 177, June 1957.

An Evaluation of Methods for Cooling Potatoes in Long Island Storages. MRR No. 494, June 1961.

From the Maine Agricultural Experiment Station, Orono, Maine:

Methods of Receiving Potatoes in Barrels at Maine Trackside Storages. Maine Agricultural Experiment Station Bulletin 560. June 1957.

Mechanized Methods of Receiving Potatoes at Maine Trackside Storages. Maine Agricultural Experiment Station Bulletin 585. September 1959.

Washington, D. C. September 1963

CONTENTS

SUMMARY

Because more and more potatoes are being processed into chips, flakes, granules, and other products, it has become increasingly important to develop better methods for moving potatoes from storages and packinghouses in the producing areas to the processing plants.

This report deals with bulk handling and shipping of potatoes in semi-trailer trucks. It covers the costs of the complete cycle--production-point packer to processor--for labor, equipment, space, transportation between plants, and truck tieup time. It also compares costs of bulk handling and shipping with those for the pallet-box and burlap-bag methods described in an earlier report (MRR No. 495; see list of related publications in preface).

This report evaluates loading out of potatoes directly from the packing line, placing them into temporary storage, and loading them out from temporary storages with capacities of 800 and 1,200 hundredweight (cwt.). One method studied employs a cleated-belt elevating conveyor with a trough-belt, track-mounted telescoping conveyor to load out; and another method, a bucket elevator with a fixed-length, track-mounted conveyor. Costs for these methods are based on two packing rates, 120 cwt. per hour and 96,000 cwt. per year, and 240 cwt. per hour and 192,000 cwt. per year. Conveyors move the potatoes from the semi-trailer truck and place them in pallet boxes at the processing plant. It was assumed that the processor would use the potatoes at a rate of 60 cwt. per hour and 249,600 cwt. annually. The distance between the packer and processor was assumed to be 700 miles.

The method using the telescoping conveyor was lower in cost than the method using the fixed-length conveyor. Placing into temporary storages and loading

out from temporary storages at capacities of both 800 and 1,200 cwt. was lower in cost than loading out directly from the packing line.

The burlap-bag method cost less than the bulk or the pallet-box method when packing was at a rate of 120 cwt. per hour at an annual volume of 96,000 cwt., and when loading out from temporary storages with capacities of approximately 1,200 and 2,400 cwt. At a packing rate of 240 cwt. per hour and an annual volume of 192,000 cwt., the bulk method cost least.

HANDLING AND SHIPPING POTATOES IN BULK TO PROCESSING PLANTS

by Leonard Pawski, industrial engineer 1/
Transportation and Facilities Research Division

BACKGROUND

Increased demand for potatoes for processing into chips, flakes, granules, and other products has intensified interest in shipping potatoes in bulk rather than in burlap bags. A third method, currently used on a very limited scale, is shipping in 1-ton-capacity collapsible wooden pallet boxes. This method was evaluated in an earlier report. 2/

A study was undertaken to evaluate many factors involved in handling potatoes in bulk, from packing and handling at the grower level through receiving and handling at the processor level, with the objective of developing better handling methods and reducing costs.

Methods currently being used by growers and processors were studied, and data collected. These and other data were then used to synthesize methods for various conditions and to make comparisons with methods described in the earlier report. Consequently, methods and conditions described in this report do not represent entirely those found in the plant of any of the cooperators mentioned in the preface of this report.

This study considered the costs of labor, equipment, shipment of bulk bins in a truck to and from the processor, space required, and truck tieup time.

No attempt was made to determine the injury caused to the potatoes by the equipment used in these methods. Consequently, losses from injury to the potatoes are not included.

In comparisons of costs of these methods, it was considered that the cycle begins just after the sorting operation at the shipping point. The cycle includes loading the potatoes into trucks, transporting them, and unloading the potatoes and supplying the processing line at the processing plant.

Costs are based on packing and handling rates at the packing plant of 120 and 240 hundredweight (cwt.) per hour, 960 and 1,920 cwt. per day for 100 days, and annual volumes of 96,000 and 192,000 cwt. Methods covered include (1) loading out directly from the packing line, and (2) placing in and loading out from temporary storages having capacities of 800 and 1,200 cwt.

1/ Mr. Pawski has resigned from AMS since this study was made.

2/ Pawski, Leonard, and Findlen, Herbert, "Handling and Shipping Potatoes to Processing Plants in Pallet Boxes and Burlap Bags." Mktg. Res. Rpt. No. 495. U. S. Dept. Agr. September 1961. 34 pp., illus.

Handling to and supplying the processing lines at the processing plant was based on a rate of 60 cwt. per hour, 960 cwt. per day for 260 days, and annual volume of 249,600 cwt.

A truckload is considered to be 400 cwt. of bulk potatoes. The transportation distance between the packer and processor is assumed to be 700 miles.

METHODS

Operations at Packinghouse

Direct Loading

Method A.--A caster-mounted cleated-belt conveyor, 36 inches wide, is used to carry the potatoes from a conveyor at the end of the sorting table onto an 18-inch trough-belt, track-mounted, telescoping conveyor which moves the potatoes into the truck (figs. 1 to 3).

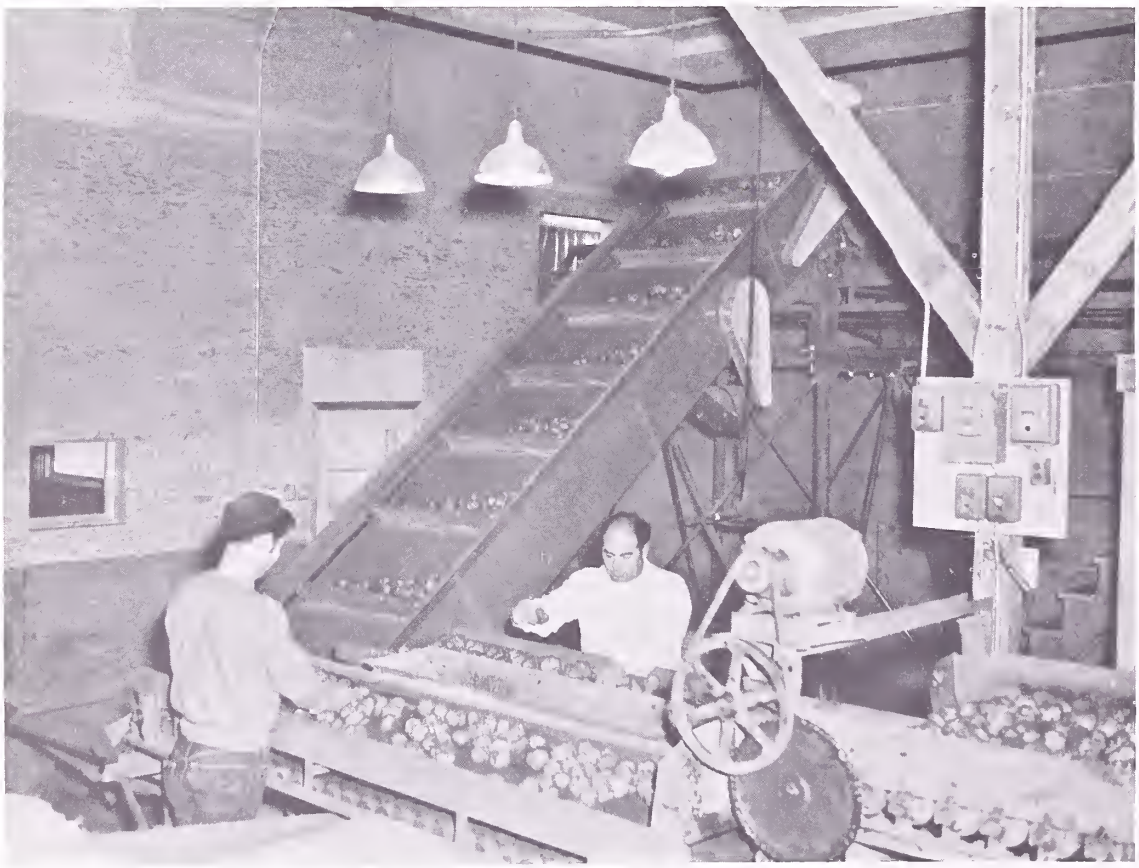

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Figure 1.--Sorted potatoes are elevated from the sorting table to the telescoping trough-belt conveyor by means of the cleated-belt conveyor.

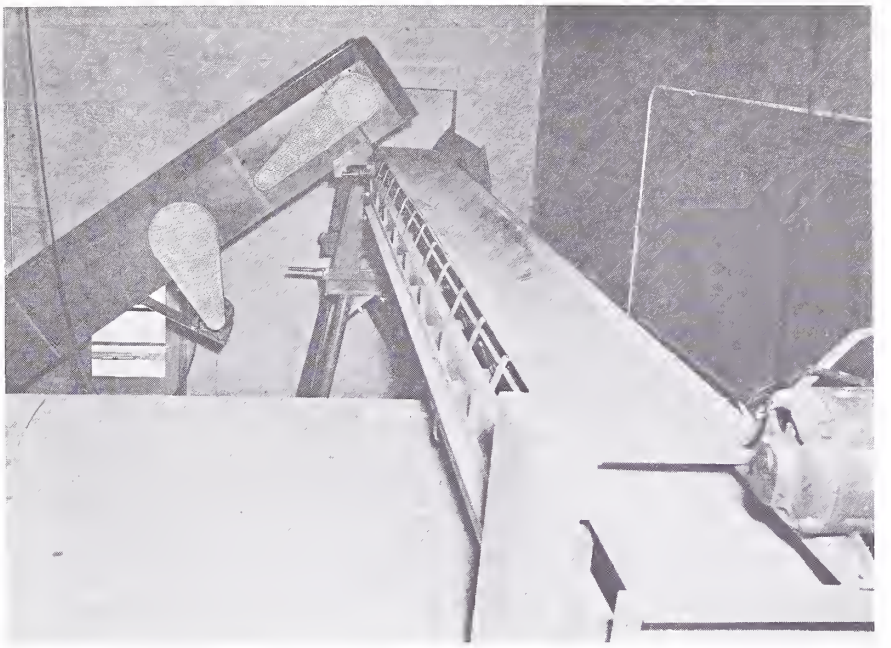

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Figure 2.--Telescoping trough-belt conveyor, that moves potatoes into a truck, in telescoped and retracted position. Elevating cleated-belt conveyor is in side view at left.

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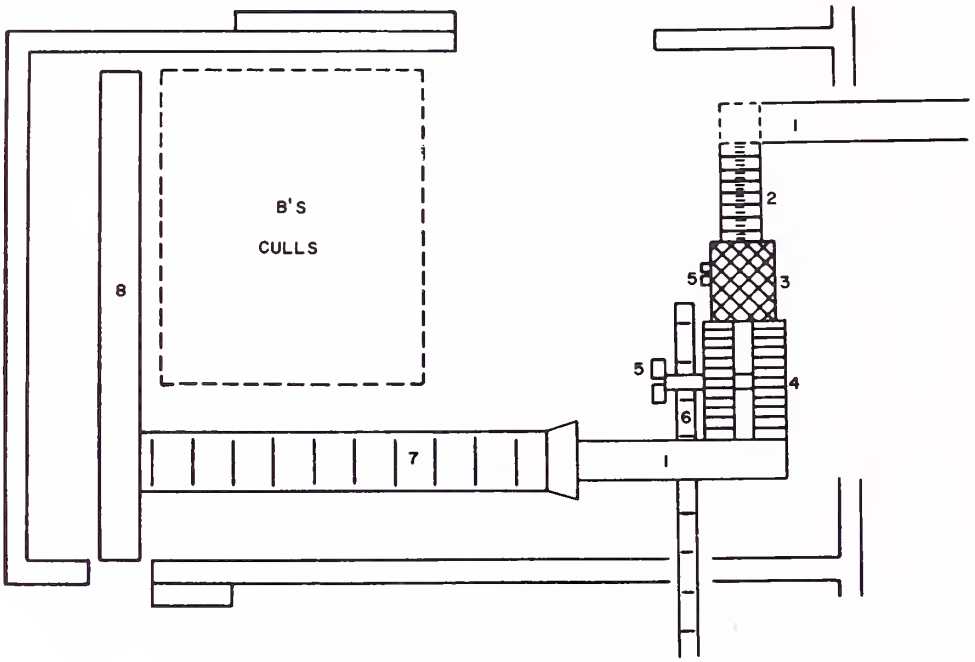
Figure 3.--Loading potatoes in a truck, with the telescoping trough-belt conveyor extended. Hand crank is visible at right side of conveyor.

This method is used also for packing and loading out 100-pound burlap bags of potatoes. To do this, bagging heads are installed on the end of the sorting table, the elevator is moved toward the wall, and after the bags have been hand-stitched they are placed on the elevating conveyor and conveyed to the trough-belt conveyor and into the truck.

The trough-belt conveyor is retracted, extended, telescoped, and projected with a hand crank (fig. 3).

To permit comparisons with operations described in the report, "Handling and Shipping Potatoes to Processing Plants in Pallet Boxes and Burlap Bags," a layout as shown in figure 4 is used in this study.



INSIDE DIMENSIONS
WIDTH —— 26'
LENGTH —— 40'
HEIGHT —— 14'

CODE
1 CONVEYOR
2 DRAPER CHAIN CONVEYOR
3 SCREEN SIZER
4 SORTING TABLE
5 BAGGING HEAD
6 B & CULL CONVEYOR
7 CLEATED BELT CONVEYOR
8 TELESCOPING CONVEYOR

BN 18413

Figure 4.--Layout of method A, using a movable cleated-belt elevating conveyor and a track-mounted telescoping conveyor.

Method B.--Another method evaluated and in use today in a ground-level packinghouse employs a bucket elevator to move bulk potatoes 3/ onto a fixed-length track-mounted conveyor. The conveyor is used also for loading out 100-pound bags of potatoes, but another bucket elevator is used to move the bags onto the conveyor.

The layout shown in figure 5 was used in this study. A flat-belt movable conveyor was used to feed potatoes from the stationary packing line to the bulk bucket elevator.

3/ Edgar, A. D., Glaves, A. H., and Hansen, J. C., An Improved Elevator for Deep Bin Potato Storages. Mktg. Res. Rpt. No. 131. U. S. Dept. Agr. August 1956.

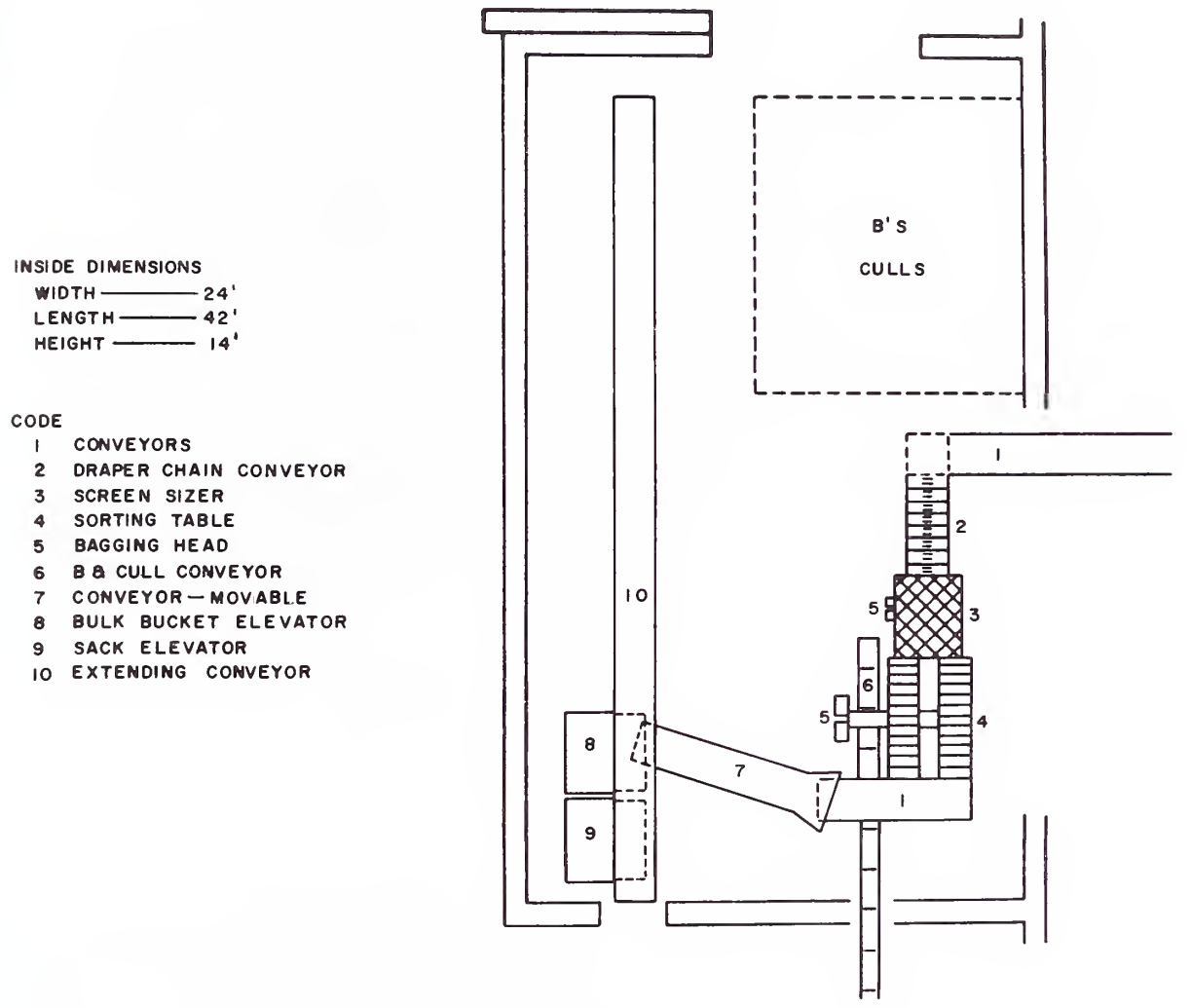


Figure 5.--Layout of method B, using a movable flat-belt conveyor, bulk bucket and bag elevators, and fixed-length, track-mounted conveyor.

Figures 6 and 7 show the movable flat-belt conveyor, bulk and bag elevators, and the fixed-length conveyor. The fixed-length conveyor is retracted and advanced electrically and is controlled by the worker in the truck. A front section of the conveyor is pivoted and can be raised and lowered with a hand hydraulic pump.

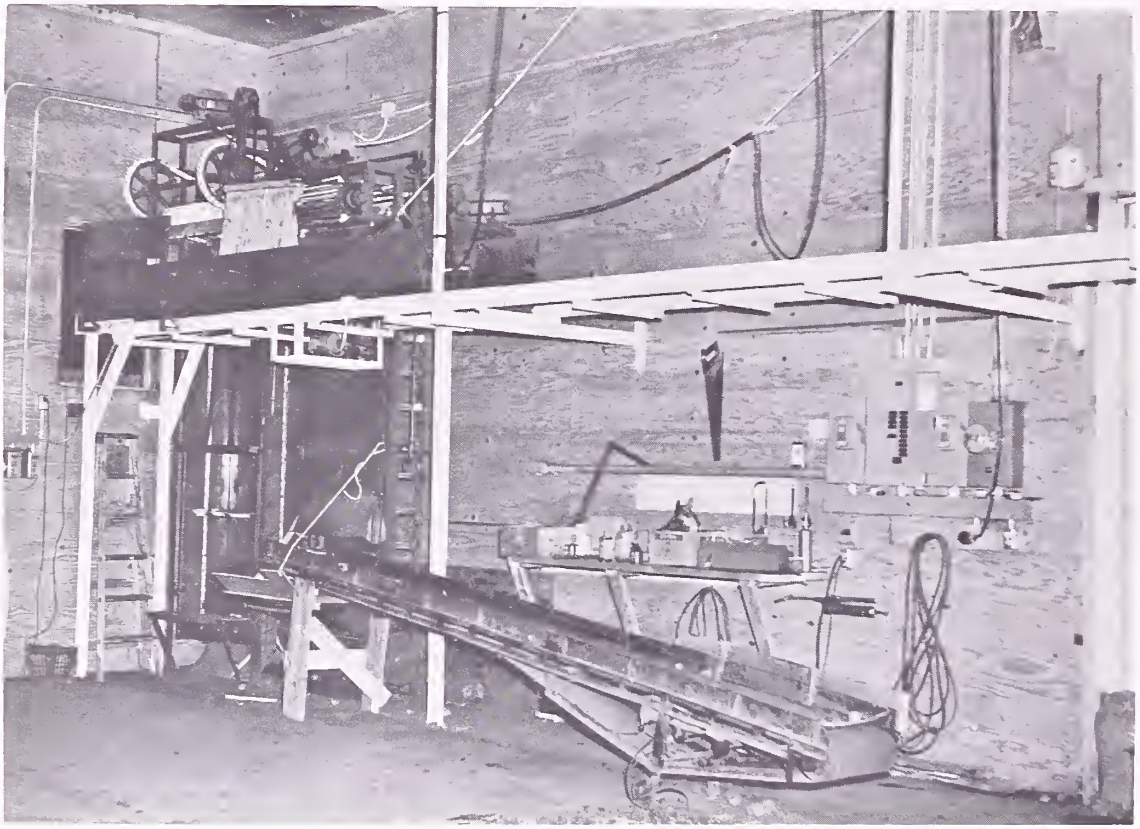


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Figure 6.--Fixed-length, track-mounted conveyor advanced through opening in wall at upper left. Bucket and bag elevating conveyors are visible at left, and movable flat-belt conveyor is at bottom.

Temporary Storage

Current bulk packing and loading procedures do not provide for storing graded bulk potatoes. A truck must be available for loading at all times, to avoid wait time for the whole crew because of stoppage of operations; and there is usually a brief delay when a full truck moves out and is replaced by an empty one. Also, when loading directly, the truck tieup time is governed by the time required to pack and load out a truckload. To reduce or eliminate wait time of trucks while potatoes are being sorted, and of the packinghouse crew while a truck is not available for loading, a method was developed for temporary

BN 18443

Figure 7.--Bulk bucket elevator (right) with flat-belt-conveyor extending into it; part of bag elevator is visible at left.

storage of sorted potatoes (fig. 8). Potatoes can be loaded directly into trucks from this temporary storage. The system consists of a 36-inch belt conveyor and divider, a bucket elevator, a bin-filling conveyor equipped with a plow that shunts the potatoes off the conveyor into the bin, and two or three bulk hopper-bottom storage bins each with a capacity of 400 cwt. A feeder and a belt conveyor are installed in the bottom of each bin (fig. 9). The front end of each bin (the end closest to the bucket elevator) is inclined and equipped with baffles (fig. 10).

Potatoes from the sorting table are moved by the 36-inch divided-belt conveyor. The potatoes are diverted to the 12-inch channel of the feed belt conveyor, where they are either allowed to go directly to the loading-out equipment or are diverted (plowed off) into the bucket elevator. The bucket elevator lifts the potatoes onto the bin-filling conveyor. The first potatoes entering an empty bin are diverted by the plow onto the inclined end of the bin and roll through a series of baffles to the bottom of the bin, in which an inclined pile of potatoes builds up. When the peak of the pile reaches the level of the conveyor, the plow is moved back to allow the potatoes to enter at the top of the pile to fill the rest of the bin. To fill other bins, the bucket elevator and the bin-filling conveyor are moved independently and the operation is repeated.

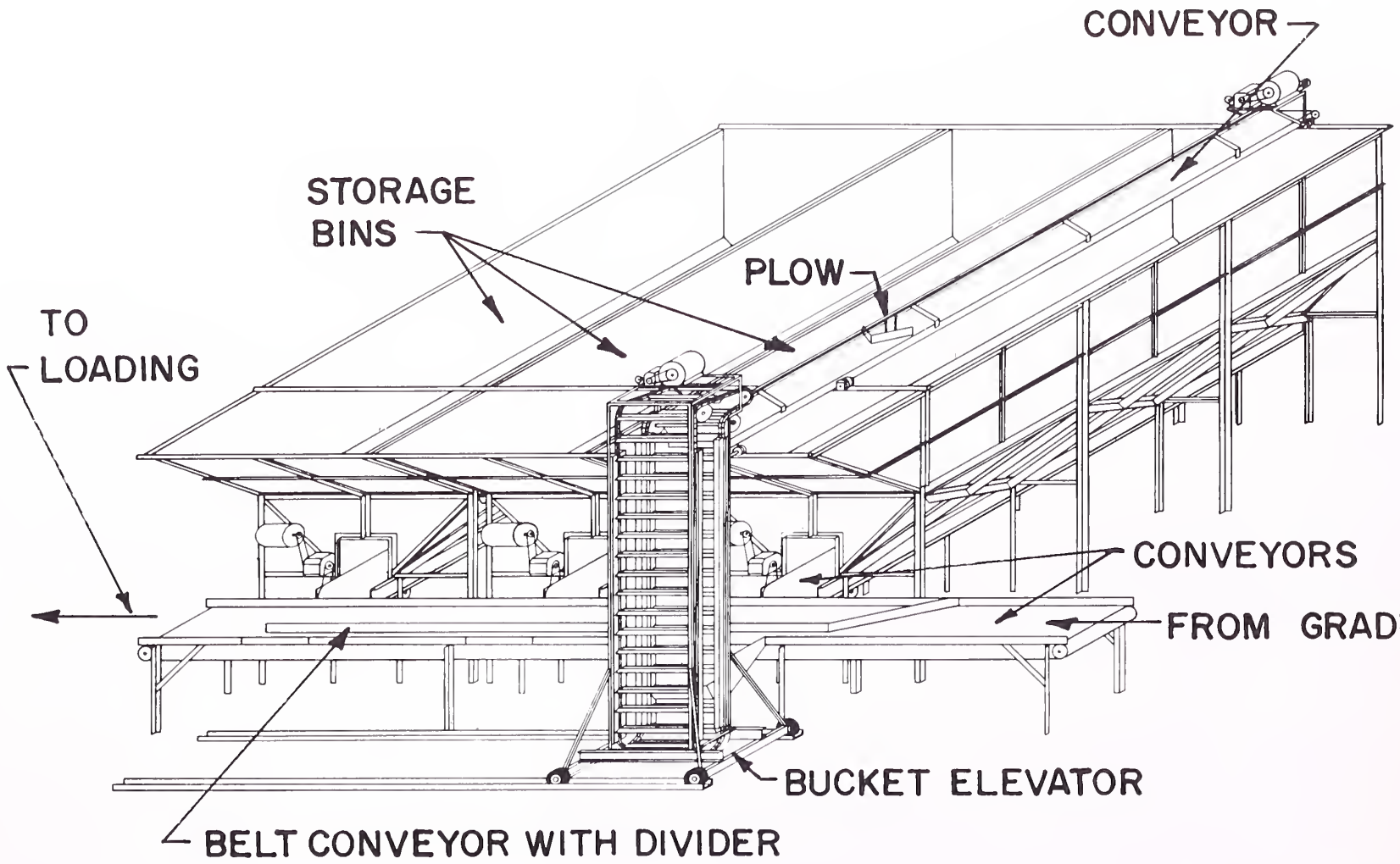

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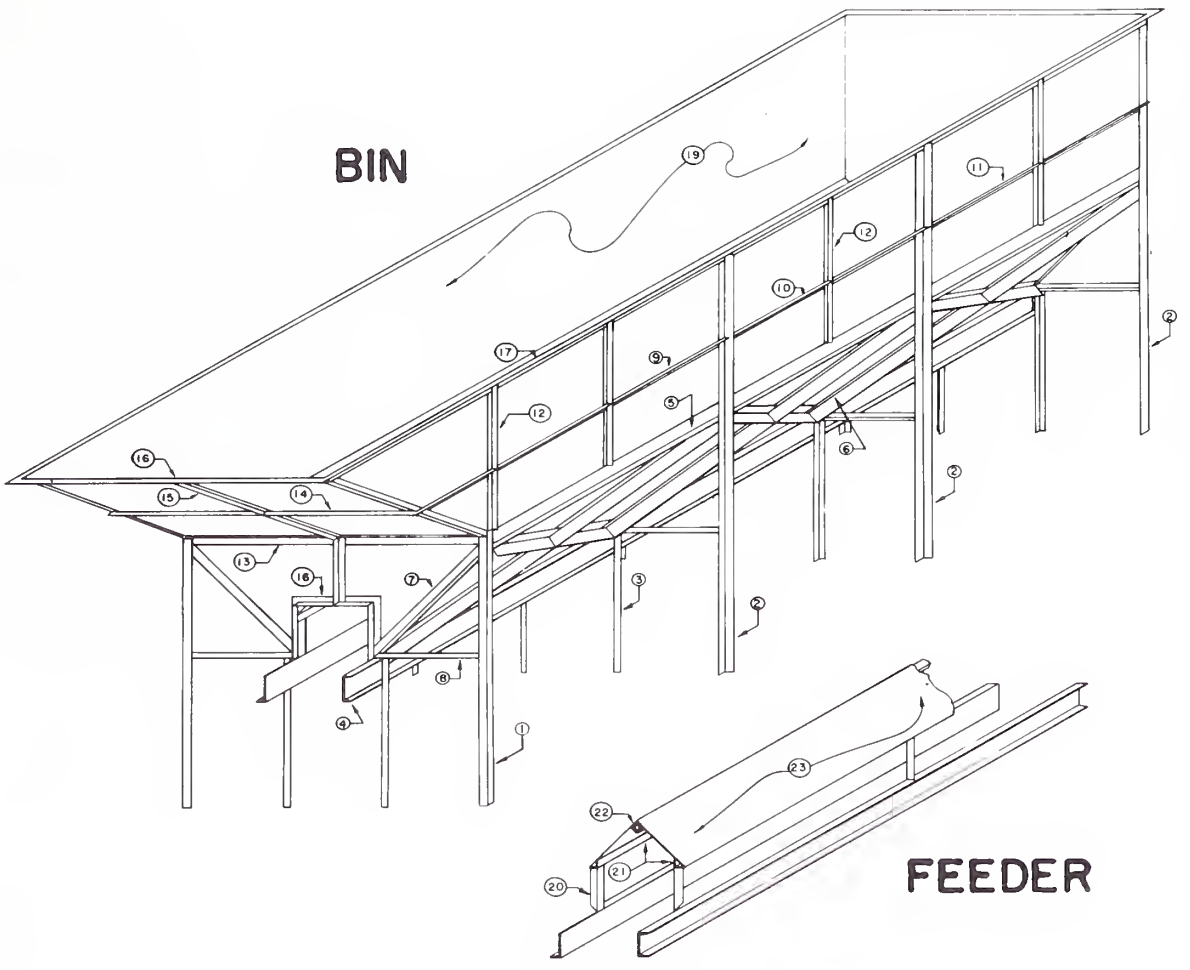
Figure 8.--Equipment for temporary storage of graded potatoes, consisting of a divided 36-inch belt conveyor, bucket elevator, bin-filling conveyor and plow, hopper-bottom storage bins equipped with feeder, and belt conveyor at the bottom of each bin.



BULK BIN
PART LIST

Part No	Name of Part	No.	Material	Wt Per Lin.Ft.-lb	Total Wt-lb
1	Front Leg	2	7'-5"x2½"x2½"x3/16" ∠	3.07	46
2	Center & Rear Leg	6	11'-4"x2½"x2½"x3/16" ∠	3.07	209
3	Conveyor Leg	8	4'x 1½"x 1½"x 3/16" ∠	1.64	52
4	Lower Sill	2	21'x 8"x 2'7/64" Channel	11.50	483
5	Upper Sill	2	20'x 4"x 4"x 3/8" ∠	9.80	392
6	Floor Support	12	8'-2"x 4"x 4"x 3/8" ∠	9.80	961
7	Floor Support	4	4'-3"x 2½"x 2½"x 3/16" ∠	3.07	52
8	Leg Brace	8	3'x 1½"x 1½"x 3/16" ∠	1.80	43
9	Side Bace	2	9'-2"x 1½"x 1¼"x 3/16" ∠	1.64	30
10	Side Brace	2	6'x 1½"x 1¼"x 3/16" ∠	1.64	20
11	Side Brace	2	6'-7"x 1½"x 1¼"x 3/16" ∠	1.64	22
12	Side Brace	8	4'x 1½"x 1¼"x 3/16" ∠	1.64	52
13	End Brace	2	8'x 2"x 2"x 3/16" ∠	2.44	39
14	End Brace	2	8'-3"x 2"x 2"x 3/16" ∠	2.44	40
15	End Brace	2	7'-8"x 2"x 2"x 3/16" ∠	2.44	37
16	End Plate	2	8'-5"x 2½"x 2½"x 3/16" ∠	3.07	52
17	Side Plate	2	25'x 2½"x 2½"x 3/16" ∠	3.07	154
18	Conveyor Opening	1	5'x 2"x 2"x 3/16" ∠	2.44	12
19	Sheet Metal		458 ft²	5.00 lb/ft²	2280
20	Conveyor Feeder Leg	8	14"x 2½"x 2½"x 3/16" ∠	3.07	29
21	Conveyor Feeder Sill	2	20'x 3"x 3"x 5/16" ∠	6.10	244
22	Conveyor Feeder Ridge	1	20'x 2½"x 1/4" Hollow Square	7.65	153
23	Sheet Metal		70 ft²	5.00 lb/ft²	350

Figure 9.--Construction details of one of the bulk hopper-bottom storage bins and feeder.

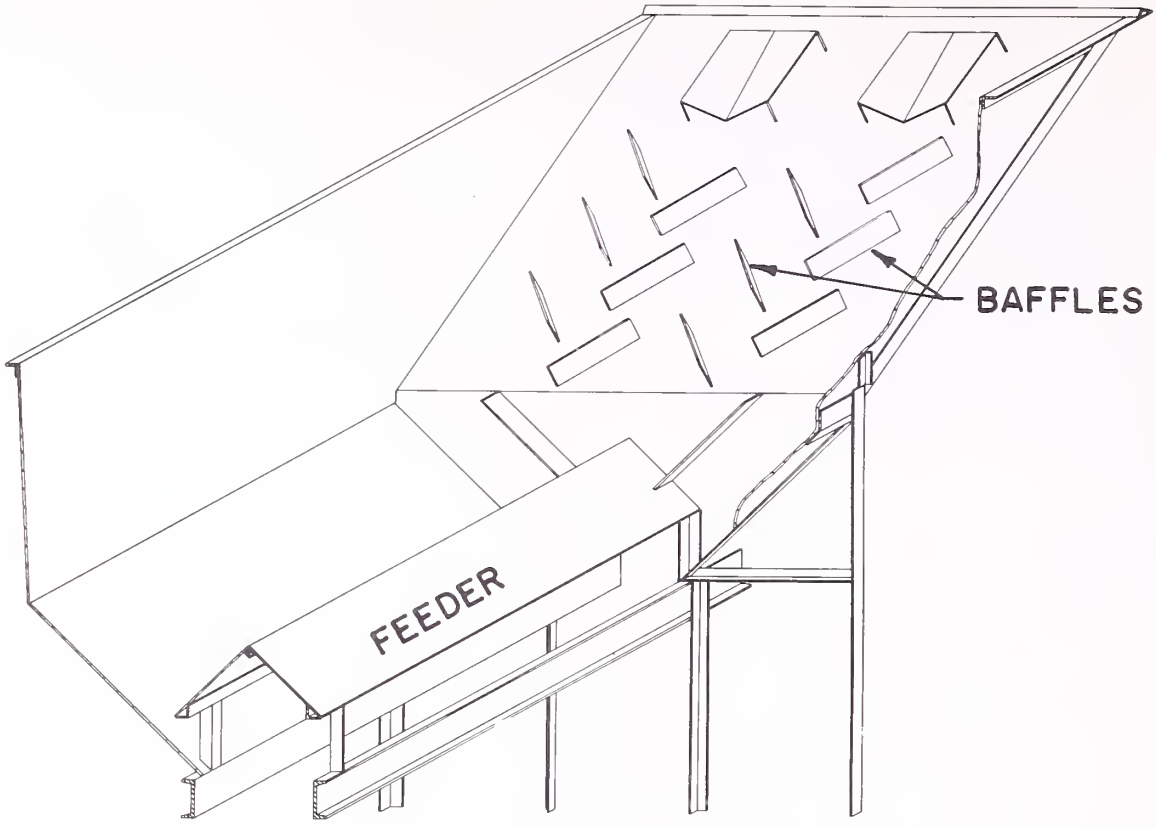


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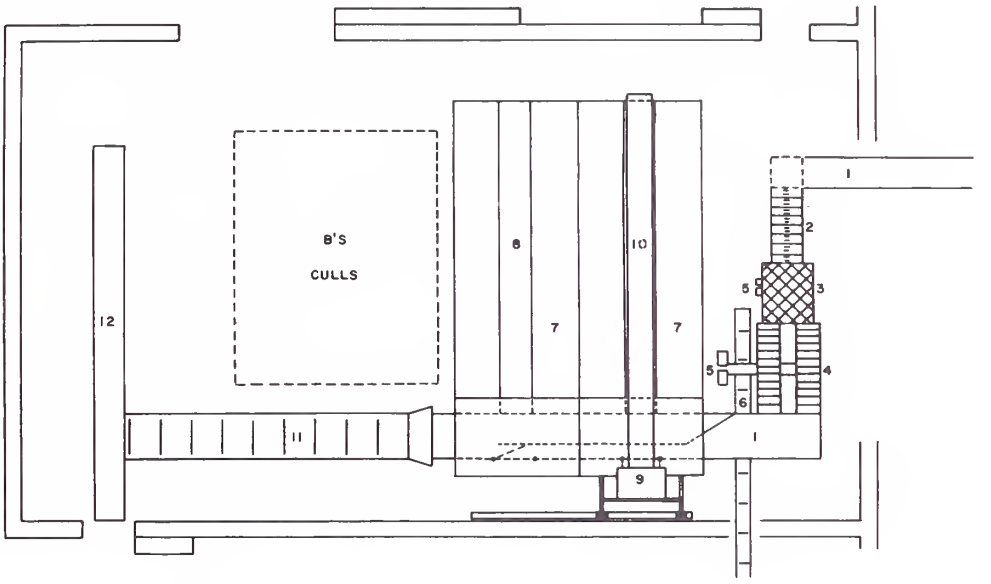
Figure 10.--Cross section of a (bulk) hopper-bottom storage bin showing the baffles used to start filling the bin to provide an inclined pile, and the feeder in bottom. Each of the bins is so designed and equipped.

The bin is emptied as the potatoes flow through the feeder (fig. 10) onto the belt conveyor in the bottom of each of the bins. The conveyor moves the potatoes to the divided-belt conveyor, which in turn carries the potatoes to the loading-out equipment.

In this method, potatoes can be loaded directly from the packing line and the storage bin simultaneously, or they can be loaded out from the storage bin only, while the potatoes coming from the packing line are placed into another bin.

When the system of temporary storage is incorporated with method A, each bin (capacity 400 cwt.) can be emptied and loaded out in 35.56 minutes. When the system is used with method B, however, the capacity of the bucket elevator used to move the potatoes onto the fixed-length, track-mounted conveyor must be increased to achieve this time. This can be done by adding another rod in the bucket, changing its width from 5-1/8 to 6-7/8 inches, and lengthening the buckets from 30 to 36 inches.

Method C, Direct and Indirect Loading (800-cwt. Storage).--This method is the same as method A except that it incorporates a temporary storage of 800 cwt.--two 400-cwt. bins (fig. 11).



INSIDE DIMENSIONS
WIDTH — 32'
LENGTH — 54'
HEIGHT — 16'

CODE
1 CONVEYOR
2 DRAPER CHAIN CONVEYOR
3 SCREEN SIZER
4 SORTING TABLE
5 BAGGING HEAD
6 BB CULL CONVEYOR
7 HOPPER BINS
8 BIN CONVEYOR-BELT
9 BULK BUCKET ELEVATOR ON TRACK
10 OVERHEAD BIN CONVEYOR ON TRACK
11 CLEATED BELT CONVEYOR
12 TELESCOPING CONVEYOR

BN 18417

Figure 11.--Layout of method C, using two temporary storage bins, bin-filling conveyor, bucket elevator, feed conveyor, elevating conveyor, and telescoping conveyor.

Method D, Direct and Indirect Loading (800-cwt. Storage).--This method is the same as method B except that it incorporates a temporary storage of 800 cwt. (fig. 12).

Method E, Direct and Indirect Loading (1,200-cwt. Storage).--This method is the same as methods A and C except that it incorporates a temporary storage of 1,200 cwt.--three 400-cwt. bins (fig. 13).

Method F, Direct and Indirect Loading (1,200-cwt. Storage).--This method is the same as methods B and D except that it incorporates a temporary storage of 1,200 cwt. (fig. 14).

INSIDE DIMENSIONS,
WIDTH ——— 42'
LENGTH ——— 42'
HEIGTH ——— 16'

CODE
1 CONVEYOR
2 DRAPER CHAIN CONVEYOR
3 SCREEN SIZER
4 SORTING TABLE
5 BAGGING HEAD
6 B& CULL CONVEYOR
7 HOPPER BINS
8 BIN CONVEYOR — BELT
9 BULK BUCKET ELEVATOR ON TRACK
10 OVERHEAD BIN CONVEYOR ON TRACK
11 CONVEYOR — MOVEABLE
12 BULK BUCKET ELEVATOR
13 SACK ELEVATOR
14 EXTENDING CONVEYOR

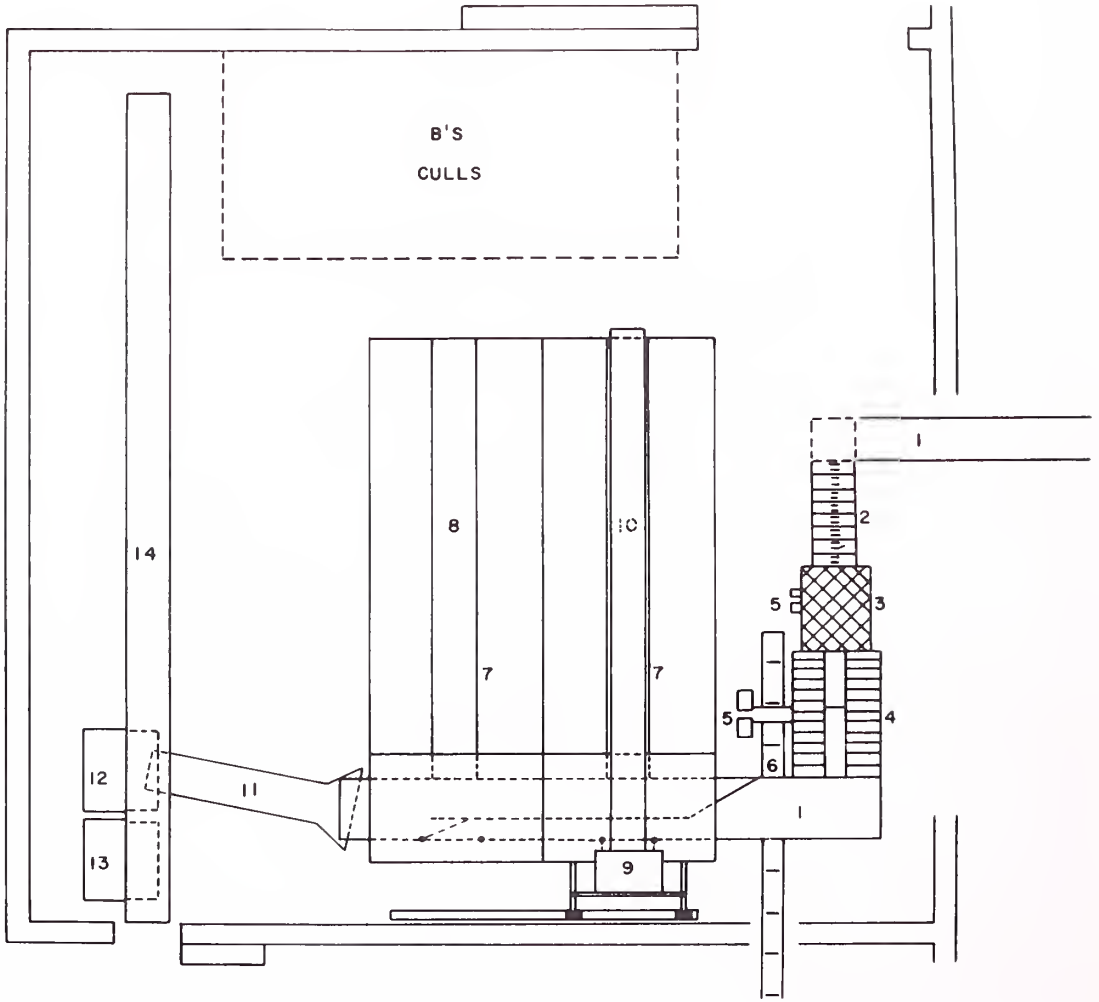


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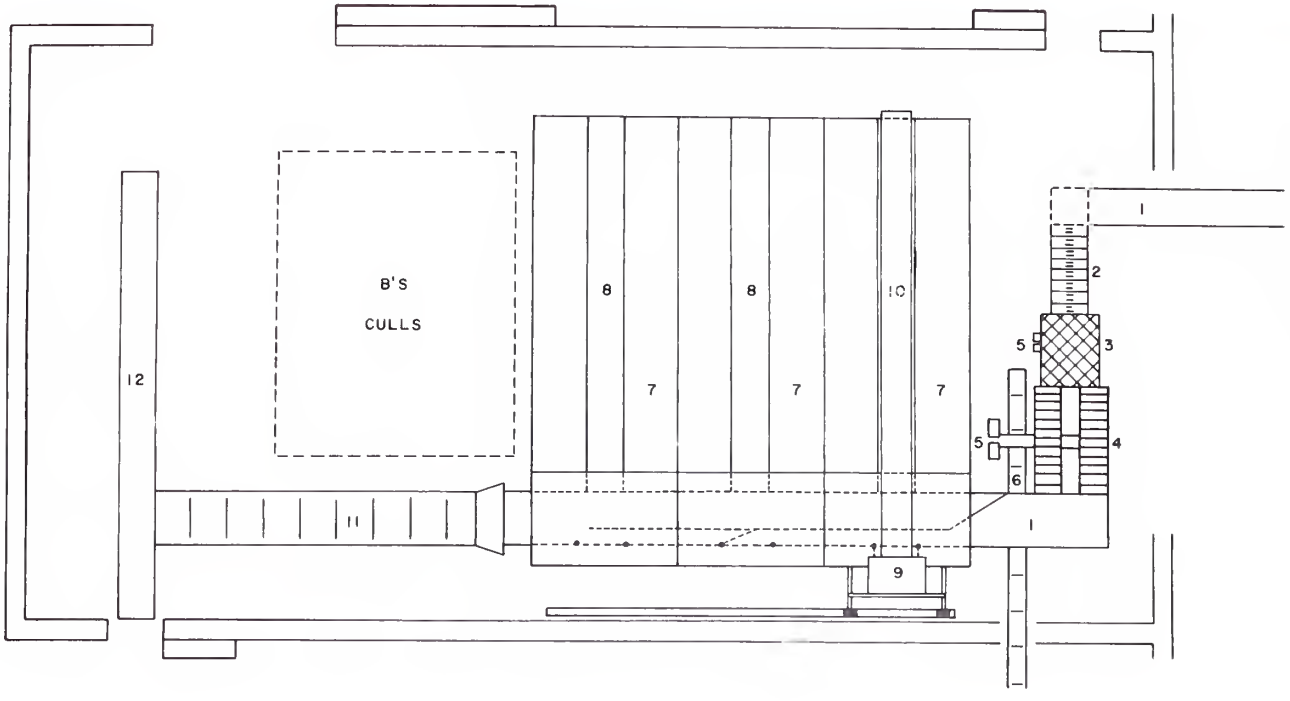
Figure 12.--Layout of method D, using two temporary storage bins, bin-filling conveyor, bucket elevator, feed conveyor, movable flat-belt conveyor, bulk bucket and sack elevator, and fixed-length track-mounted conveyor.



INSIDE DIMENSIONS
WIDTH — 32'
LENGTH — 62'
HEIGHT — 16'

CODE
1 CONVEYOR
2 DRAPER CHAIN CONVEYOR
3 SCREEN SIZER
4 SORTING TABLE
5 BAGGING HEAD
6 B & CULL CONVEYOR
7 HOPPER BINS
8 BIN CONVEYOR — BELT
9 BULK BUCKET ELEVATOR ON TRACK
10 OVERHEAD BIN CONVEYOR ON TRACK
11 CLEATED BELT CONVEYOR
12 TELESCOPING CONVEYOR

BN 18408

Figure 13.--Layout of method E, using three temporary storage bins, bin-filling conveyor, bucket elevator, feed conveyor, elevating conveyor, and telescoping conveyor.

INSIDE DIMENSIONS
WIDTH ——— 42'
LENGTH ——— 50'
HEIGTH ——— 16'

CODE
1 CONVEYOR
2 DRAPER CHAIN CONVEYOR
3 SCREEN SIZER
4 SORTING TABLE
5 BAGGING HEAD
6 B & CULL CONVEYOR
7 HOPPER BINS
8 BIN CONVEYOR — BELT
9 BULK BUCKET ELEVATOR ON TRACK
10 OVERHEAD BIN CONVEYOR ON TRACK
11 CONVEYOR — MOVEABLE
12 BULK BUCKET ELEVATOR
13 SACK ELEVATOR
14 EXTENDING CONVEYOR

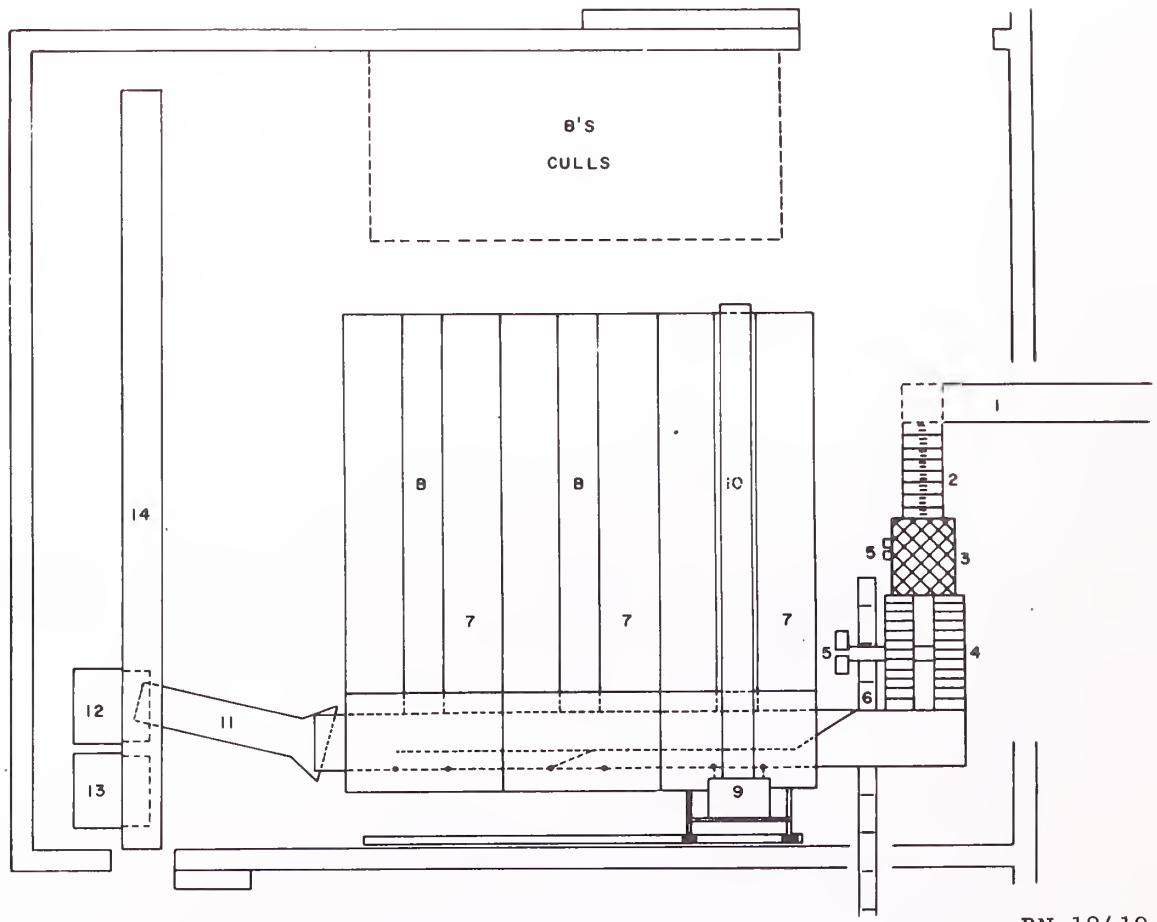


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Figure 14.--Layout of method F, using three temporary storage bins, bin-filling conveyor, bucket elevator, feed conveyor, movable flat-belt conveyor, bulk bucket and sack elevator, and fixed-length track-mounted conveyor.

Operations at Processing Plant

A method was synthesized to allow unloading of bulk potatoes from a truck at the processor's plant and placing them into pallet boxes for temporary holding. 4/ The method is similar to that used in filling boxes at a grower's storage during harvest (fig. 15). Equipment used is a cleated-belt conveyor, a box tipper, and a roller conveyor.

BN 12432X

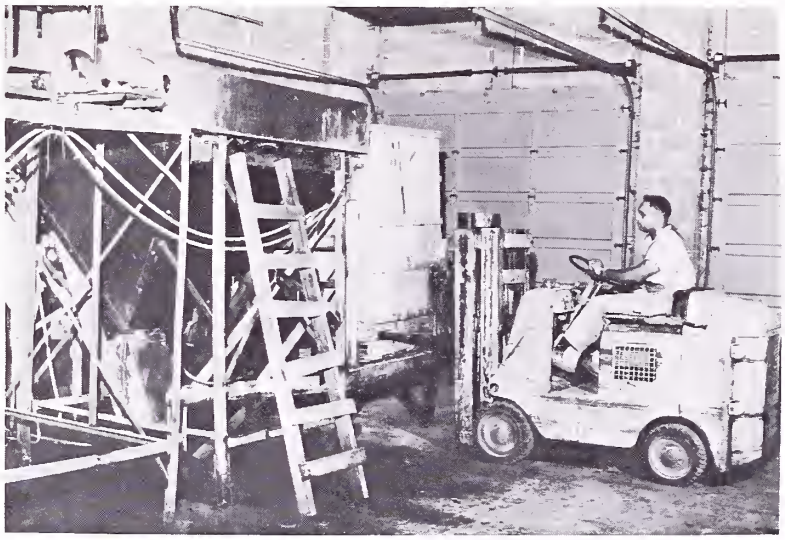
Figure 15.--Filling pallet boxes at a grower's storage. Potatoes are unloaded from the conveyor in the truck onto a cleated-belt conveyor that carries them into a pallet box held on a box tipper. A roller conveyor holds empty and filled boxes.

Potatoes are unloaded by the conveyor in the truck (see section following for description of this conveyor) onto the cleated-belt conveyor, which leads into the processing plant. The cleated-belt conveyor carries the potatoes into a pallet box held on a box tipper. The box tipper reduces the drop of potatoes falling into the box by raising the box before filling starts and lowering it as it is filled. After a box has been filled, it is moved aside and an empty box is moved onto the tipper.

The pallet box is a collapsible type, 40 inches wide, 43 inches long, and 60 inches high. It is held together by four wire ties at each of the corners, and the four sides are fastened to the pallet by a wire tie on each side. A box tipper to accommodate a 5-foot-high box is used.

4/ See footnote 2, p. 7.

A forklift truck is used to remove pallet boxes from the roller conveyor, transport them, and stack them three high in storage. Potatoes are usually removed from storage and supplied to the processing line one row of boxes at a time, on a first-in, first-out basis. A box tipper is used at the head of each processing line to raise the boxes and empty the potatoes into the hopper that feeds the line (figs. 16 and 17).



BN 11956

Figure 16.--Pallet box of potatoes being placed on the box tipper at the processing line.

BN 11957

Figure 17.--Pallet box of potatoes is emptied by box tipper into the hopper that feeds the processing line.

After the box has been emptied and lowered, it is removed from the tipper and placed on the roller conveyor used in receiving boxes of potatoes or placed in temporary storage until required.

Figure 18 shows the layout used with this method. The method and layout allow integration of bag handling with pallet-box handling; potatoes received in bags can be emptied onto the cleated-belt conveyor and loaded into pallet boxes.

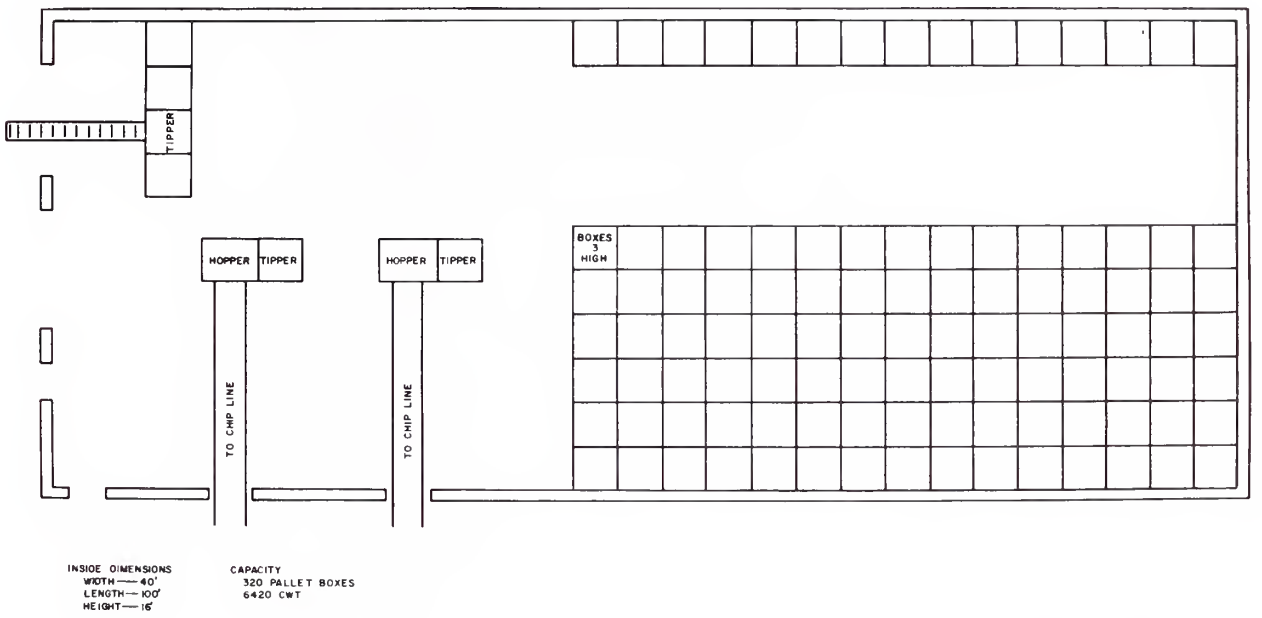


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Figure 18.--Layout for the bulk operation at the processing plant.

Transportation

To prevent damage to potatoes from freezing or from going out of condition for processing while being transported in bulk in cold climates, it is necessary to install a bulk bin within the trailer to allow air to circulate around the potatoes. The bin serves as a container for the potatoes.

The bin for the trailer is 32 feet long by 7½ feet wide. A 7½-inch airspace is between the floor of the bin and the truck. Walls of the bin are 4 feet above the bin floor; total wall height is 4 feet 8¼ inches.

An airspace of 2 inches is provided between the walls of the bin and of the truck. The large airspace at the floor is the space required by the unloading conveyor. The bin is made in sections 8 feet long so that it can easily be installed and removed. The bin has 2- by 2-inch stringers in the side walls and 2- by 8-inch stringers in the floor, with sidewalls of 3/8-inch plywood and floor of 3/4-inch plywood. The front and back walls of the bin are made of 2- by 8-inch boards.

An 8-inch chain-driven belt conveyor extends the full length of the trailer, past the end of the bin to the tailgate, along the center of the floor (figs. 19 and 20). The conveyor covering is 1-inch pine. The weight of the bin and conveyor is approximately 2,150 pounds.

BN 18447

Figure 19.--A bulk bin installed in a semi-trailer truck. Note trailer-length conveyor in center of trailer below bin floor. Conveyor cover boards are in place.

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Figure 20.--Rear view of semitrailer (with tailgate doors open) in which a bulk bin is installed.

COSTS

Labor

In computing the costs of labor, an assumed wage rate of $1 per hour is used for all operations at the packinghouse and a rate of $1.45 per hour at the processing plant.

When loading directly from the packing line, as in methods A and B, one man loads and handles the equipment in the truck. The other man bags and handles B-size potatoes and assists in retracting the telescoping conveyor. If B-size potatoes were not bagged and were disposed of through the cull conveyor, one man would be sufficient. However, in the method using a telescoping conveyor, a worker from the sorting operation would be required to assist in retracting the conveyor, thereby causing a slight delay. In this study, it is considered that the B-size potatoes are bagged.

When placing potatoes into temporary storage before loading out, as in methods C, D, E, and F, one man loads and handles the equipment in the truck. The other man handles storing and unloading of the bin, and also bags and handles B's and assists with the telescoping conveyor. After the truck is loaded, both men perform the storing and B-handling operation.

For all methods, since all use two-man crews, the cost of labor at the packinghouse per cwt. of potatoes is:

Packing 120 cwt. per hour, 960 cwt. per day.....$0.0167
Packing 240 cwt. per hour, 1,920 cwt. per day.....$0.0083

Unloading, placing potatoes into pallet boxes, and handling into and out of storage at the processing plant require a three-man crew. One man works in the truck. He removes the boards over the conveyor and controls the flow of potatoes onto the conveyor by pushing potatoes onto the conveyor when they will not flow on by gravity. The second man fills the pallet boxes, operates the box tipper, and controls the operation of the conveyor and tipper. When a box is filled, he moves it aside on the roller conveyor and moves an empty box into position on the tipper. The third man operates the forklift truck. He removes the full box of potatoes from the roller conveyor, transports and places it into storage, removes it from storage, and supplies the processing line. He operates the box tipper for dumping potatoes into the hopper of the processing line, removes empty boxes, and supplies empty boxes for filling.

After a truck is unloaded, the forklift operator only is required until another truck arrives. The truck unloader and the box tipper operator work on this operation 1.43 hours per truckload of 400 cwt., processed in 6.67 hours. Labor costs for these two men are based on 1.43 hours out of every 6.67 hours. It is considered that other work on other operations in the plant is available for these two men.

The cost of labor at the processing plant, per cwt. of potatoes, to unload a truckload into pallet boxes, store, and supply the processing line with potatoes throughout 6.67 hours is: Processing rate of 60 cwt. per hour--$.0293.

Equipment

Purchase costs of handling equipment represent prices f.o.b. Grand Forks, North Dakota. Similar costs were used for the packer and processor. Equipment costs were developed into two major categories: (1) Ownership, and (2) operating.

Ownership costs include depreciation, taxes, interest, and insurance, all considered to be fixed, and are computed on an annual basis. Interest on the average investment is assumed to be 5 percent, and 4 percent is allowed for insurance and taxes.

Operating costs include maintenance, repairs, inspection and servicing, fuel, oil, and electricity. The cost for maintenance, repair, inspection, and servicing for all units was estimated at 1½ percent of the replacement cost per 100 hours of use, except for the following: (a) 3,000-pound-capacity forklift truck at $0.184 per hour of use; (b) pallet box at $0.84 per year, and (c) bulk bins in trucks at $2.40 per year.

Gasoline cost was considered to be $0.23 per gallon and oil $0.40 per quart. Electricity cost was considered to be $0.02 per kilowatt-hour.

Although a gasoline-fueled forklift truck was used in the comparison, it is not recommended in closed atmospheres. A forklift model with a bottled gas (LP) unit would be much safer. An electrical forklift truck would eliminate the danger of carbon monoxide entirely.

Equipment costs for the transporter to handle potatoes in bulk were computed only for the bulk bins and conveyors necessary to transport the two annual volumes. With the direct methods (A and B), trucks would be delayed somewhat more than in the indirect methods (C-F), and as a result an additional unit would be required.

The comparative costs of equipment per cwt. of potatoes handled from packer through processing are presented in table 1.

Space

Layouts for each method were developed to allow space to perform the operations most efficiently. Methods C and D allow for storage of 0.83 of a day's production at the packinghouse when packing at a rate of 120 cwt. per hour. At 240 cwt. per hour, 0.42 of a day's production can be stored. Methods E and F allow for storage of 1.25 of a day's production when packing at a rate of 120 cwt. per hour and 0.63 of a day's production at 240 cwt. per hour. The layout for the processor allows for holding 6.66 days' supply of potatoes, when processing at a rate of 60 cwt. per hour. The temporary storage for packer and processor was not developed for the purpose of conditioning potatoes for processing, but to facilitate the operation, although it can be used for conditioning to a limited extent.

Estimated space costs for the packinghouse for the six methods were based on a vertical-wall building with a clear-span roof (table 15, appendix).

Table 1.--Comparative costs of equipment per cwt. of potatoes handled from packer through processor at two packing rates and annual volumes, by six methods 1/

Method	Packing rate, 120 cwt. per hr.; annual volume, 96,000 cwt.			Packing rate, 240 cwt. per hr.; annual volume, 192,000 cwt.		
	Packer	Transporter 2/	Processor 3/	Packer	Transporter 2/	Processor 3/
	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
A	0.0109	0.0034	0.0127	0.0054	0.0034	0.0127
B	.0132	.0034	.0127	.0066	.0034	.0127
C	.0223	.0031	.0127	.0117	.0032	.0127
D	.0246	.0031	.0127	.0129	.0032	.0127
E	.0257	.0031	.0127	.0134	.0032	.0127
F	.0280	.0031	.0127	.0146	.0032	.0127

1/ Ownership and operating costs are presented in tables 6 through 14 in the appendix.

2/ Based on transporting an annual volume of 96,000 and 192,000 cwt. a distance of 700 miles (see tables 12 and 13, appendix).

3/ Based on processing rate of 60 cwt. per hour and an annual volume of 249,600 cwt. for all methods.

It was considered that processing plants would be in cities, towns, and commercial areas where building costs are high. These costs vary according to location. The building cost per cubic foot of space for the processor was estimated as double that in the growing and packing area, which was used as a basis for computation. The type of building used in this report for processing plants in these areas also was a vertical-wall building with a clear-span roof (table 15, appendix).

To determine the space cost (table 15, appendix), the cost of erecting the building was estimated, depreciated over 25 years; interest of 5 percent on the average investment was added; 3 percent was allowed for taxes and insurance; and 0.5 percent per year of the initial cost was used for maintenance, to develop a total annual cost.

The total annual space cost, as presented in table 15 in the appendix, was divided by the annual volume to arrive at a space cost per cwt. (table 2).

Table 2.--Comparative cost of space per cwt. of potatoes handled from packer through processor at two packing rates and annual volumes, by six methods

Method	Packing rate, 120 cwt. per hr.; annual volume, 96,000 cwt.		Packing rate, 240 cwt. per hr.; annual volume, 192,000 cwt.	
	Packer	Processor 1/	Packer	Processor 1/
	Dollars	Dollars	Dollars	Dollars
A	0.0046	0.0128	0.0023	0.0128
B	.0044	.0128	.0022	.0128
C	.0073	.0128	.0037	.0128
D	.0075	.0128	.0038	.0128
E	.0082	.0128	.0041	.0128
F	.0084	.0128	.0042	.0128

1/ Based on processing rate of 60 cwt. per hour and annual volume of 249,600 cwt. for all methods.

Transportation

The cost of transporting the bulk bin in the semitrailer truck, when filled with potatoes and when empty, depends on the arrangement that can be made by the packer and processor with the trucking company.

Transportation cost for the tare weight of the bulk bin, when filled with potatoes, is considered to be the same on a per cwt. basis as the transportation cost of the potatoes. In this study, a rate of $0.90 per cwt. (based on the rate between Grand Forks, N. Dak., and Kansas City, Mo.) was used for transporting potatoes and bin a distance of approximately 700 miles. Since the weight of the empty bulk bin is 2,150 pounds, the cost of transporting the bin only, when filled with potatoes, from the packer to the processor is $19.35 (21.5 cwt. x $0.90), or an equivalent of $0.0484 ($19.35 per 400 cwt.) per cwt. of potatoes transported in the bin.

A cost of $12.19 is used in this study for transporting the 400-cwt.-capacity bulk bin without potatoes, when returning it to the packer for another load. This is based on the same rate, $0.567, by weight of the container, as that for returning collapsed pallet boxes to the packer. 5/ This is equivalent to

5/ See footnote 2, p. 7.

$0.0304 per cwt. ($12.19 per 400 cwt.) of potato capacity. Thus the cost of transporting the bulk bin only, both ways, amounts to $0.0788 ($0.0484 + $0.0304) per cwt. of capacity.

Truck Tieup

A truck waiting to be loaded or unloaded, or while actually being loaded or unloaded, is not earning revenue and is a cost to transportation, and should be considered in a comparison of methods. Reducing wait time and time to load and unload reduces costs for transportation. The amount of savings realized depends on the transportation schedule of the company.

In this study, cost of truck and tractor while being loaded or unloaded at the packing or processing plant was estimated at $8 an hour. This cost was applied to the time the trucks were being loaded or unloaded, to show the effect that truck tieup time has on the possible savings resulting from the method.

If a truck is not available at all times, the crew at the packinghouse will clean up, remove the dirt, do other work, and wait unless the potatoes can be placed into temporary storage until a truck is available. Methods and costs were developed, at packing rates of 120 and 240 cwt. per hour, for labor, equipment, and space for placing 800 cwt. (two truckloads) and 1,200 cwt. (three truckloads) into temporary storage and then loading out from storage, so as to reduce or eliminate wait time of the crew and reduce truck tieup time at the packinghouse.

All truck load-out times were multiplied by the $8 and divided by the hundredweight (400) capacity per truckload to arrive at a truck tieup cost per cwt. (table 3). Costs were based on the following load and unload times:

	Hours
Load directly from packing line (methods A and B) with packing rate of 120 cwt. per hr	3.333
Load directly from packing line (methods A and B) with a packing rate of 240 cwt. per hr	1.666
Load from temporary storage (methods C, D, E, and F) with a packing rate of 120 or 240 cwt. per hr	.593
Unload truck at the processing plant (all methods) with a processing rate of 60 cwt. per hr	1.430

COMPARATIVE COSTS OF ALL METHODS

The combined costs of the cycle, packer through processor, are presented in table 4.

As seen in table 4, method C, which uses a temporary storage capacity of 800 cwt. at the packinghouse, is lowest in cost of all methods. It is cheaper by $0.0413 per cwt. ($0.2648 - $0.2235) than method A, which loads directly

Table 3.--Comparative costs of truck tieup time per cwt. of potatoes loaded at the packinghouse, using six methods and two packing rates, and unloading at the processing plant, using one method and one processing rate.

Method	Packer		Processor
	Packing rate 120 cwt. per hr.	Packing rate, 240 cwt. per hr.	Processing rate, 60 cwt. per hr.
	Dollars	Dollars	Dollars
A	0.0670	0.0333	0.0286
B	.0670	.0333	.0286
C	.0119	.0119	.0286
D	.0119	.0119	.0286
E	.0119	.0119	.0286
F	.0119	.0119	.0286

only, when packing at a rate of 120 cwt. per hour. At a packing rate of 240 cwt. per hour, it is lower than method A by $0.0138 per cwt. ($0.2149 - $0.2010).

Method E, which uses a temporary storage capacity of 1,200 cwt. at the packinghouse, is lower in cost than method A by $0.0370 per cwt. ($0.2648 - $0.2278) when packing at a rate of 120 cwt. per hour. At a packing rate of 240 cwt. per hour, it is lower than method A by $0.0118 per cwt. ($0.2149 - $0.2031).

Increasing the storage capacity from 800 to 1,200 cwt. at the packinghouse increases the cost by $0.0043 per cwt. (method E $0.2278 - method C $0.2235) when packing at a rate of 120 cwt. per hour. At a packing rate of 240 cwt. per hour, the cost is increased by $0.0021 per cwt. ($0.2031 - $0.2010). However, increasing the storage capacity from 800 to 1,200 cwt. allows greater flexibility in the time between truck arrivals without causing delay.

COMPARISON OF COSTS OF BULK METHOD WITH COSTS OF BURLAP-BAG AND PALLET-BOX METHODS

The burlap-bag and pallet-box methods are discussed in the marketing research report, "Handling and Shipping Potatoes to Processing Plants in Pallet Boxes and Burlap Bags," MRR 495. To place those methods on a comparable basis with the bulk method the cost of a belt conveyor was added in both methods, to provide a belt conveyor from the sorting table to the bagging heads or cleated belt conveyors. The conveyor cost per cwt. of potatoes handled in both methods,

Table 4.--Comparative labor, equipment, and other costs for handling one cwt. of potatoes from packer through processor for two packing rates and annual volumes, by six methods

Item	Packing rate, 120 cwt. per hour; annual volume, 96,000 cwt.						Packing rate, 240 cwt. per hour; annual volume, 192,000 cwt.					
	Method						Method					
	A	B	C	D	E	F	A	B	C	D	E	F
	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.
Packer:												
Labor	0.0167	0.0167	0.0167	0.0167	0.0167	0.0167	0.0083	0.0083	0.0083	0.0083	0.0083	0.0083
Equipment	.0109	.0132	.0223	.0246	.0257	.0280	.0054	.0066	.0117	.0129	.0134	.0146
Space	.0046	.0044	.0073	.0075	.0082	.0084	.0023	.0022	.0037	.0038	.0041	.0042
Bulk bin transp. to processor	.0484	.0484	.0484	.0484	.0484	.0484	.0484	.0484	.0484	.0484	.0484	.0484
Bulk bin transp. from processor	.0304	.0304	.0304	.0304	.0304	.0304	.0304	.0304	.0304	.0304	.0304	.0304
Truck tieup	.0670	.0670	.0119	.0119	.0119	.0119	.0333	.0333	.0119	.0119	.0119	.0119
Total	.1780	.1801	.1370	.1395	.1413	.1438	.1281	.1292	.1144	.1157	.1165	.1178
	Processing rate, 60 cwt. per hour; annual volume, 249,600 cwt.											
Processor:												
Labor	.0293	.0293	.0293	.0293	.0293	.0293	.0293	.0293	.0293	.0293	.0293	.0293
Equipment	.0127	.0127	.0127	.0127	.0127	.0127	.0127	.0127	.0127	.0127	.0127	.0127
Space	.0128	.0128	.0128	.0128	.0128	.0128	.0128	.0128	.0128	.0128	.0128	.0128
Truck tieup	.0286	.0286	.0286	.0286	.0286	.0286	.0286	.0286	.0286	.0286.	.0286	.0286
Total	.0834	.0834	.0834	.0834	.0834	.0834	.0834	.0834	.0834	.0834	.0834	.0834
	Annual volume, 96,000 cwt.						Annual volume, 192,000 cwt.					
Transporter:												
Equipment (bulk bins)	.0034	.0034	.0031	.0031	.0031	.0031	.0034	.0034	.0032	.0032	.0032	.0032
Total	.0034	.0034	.0031	.0031	.0031	.0031	.0034	.0034	.0032	.0032	.0032	.0032
Total:												
Packer, processor, and transporter	.2648	.2669	.2235	.2260	.2278	.2303	.2149	.2160	.2010	.2023	.2031	.2044

at a packing rate of 120 cwt. per hour and an annual volume of 96,000 cwt., is $0.0018. When packing is at a rate of 240 cwt. per hour and an annual volume of 192,000 cwt., the cost per cwt. is $0.0009.

Since the monetary loss due to injury of the potatoes was not included in the study of bulk methods, this cost was eliminated from the burlap-bag method, to make the costs comparable.

Costs of the burlap-bag and pallet-box methods were based on a temporary storage capacity of 2,320 cwt. To put the bulk method on a comparable basis, the cost of method E was increased by adding three times the difference in cost between methods C and E.

Costs of the burlap-bag and pallet-box methods were adjusted also to allow for a comparison with the bulk method on the basis of a temporary storage capacity of 1,200 cwt.

The bulk method (E) at an annual volume of 192,000 cwt. is the cheapest (table 5).

Table 5.--Comparative costs per cwt. of potatoes handled from packer through processor for the burlap-bag, pallet-box, and bulk methods at temporary storage capacities of approximately 1,200 and 2,400 cwt.

Storage capacity	Packing rate, 120 cwt. per hr.; annual volume, 96,000 cwt.			Packing rate, 240 cwt. per hr.; annual volume, 192,000 cwt.		
	Method			Method		
	Burlap-bag	Pallet-box	Bulk	Burlap-bag	Pallet-box	Bulk
Cwt.	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
1,200	0.2139	0.2381	0.2278	0.2089	0.2298	0.2031
2,400	.2176	.2399	.2407	.2107	.2310	.2094

Table 6.--Packing plant, method A: Equipment ownership and operating costs for 100 days of operation at two packing rates and two annual volumes

Item	Units	Initial cost	Exp. life	Ownership cost				Operating cost			Total annual cost	Cost per cwt. at packing rates and annual volumes of--	
				Depreciation	Interest @ 5%	Ins. & taxes @ 4%	Total	Power	Maintenance	Total		120 cwt./hr.; 96,000 cwt./yr.	240 cwt./hr.; 192,000 cwt./yr.
	No.	Dol.	Yr.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.
Flat-belt conveyor	1	540.00	15	36.00	13.50	21.60	71.10	5.97	64.80	70.77	141.87	0.0015	0.0007
Cleated-belt elevating conveyor	1	1,145.20	15	76.35	28.63	45.81	150.79	8.96	137.42	146.38	297.17	.0031	.0015
Telescoping conveyor	1	2,340.00	15	156.00	58.50	93.60	308.10	17.90	280.80	298.70	606.80	.0063	.0032
Total		4,025.20		268.35	100.63	161.01	529.99	32.83	483.02	515.85	1,045.84	.0109	.0054

Table 7.--Packing plant, method B: Equipment ownership and operating costs for 100 days of operation at two packing rates and two annual volumes

Item	Units	Initial cost	Exp. life	Ownership cost				Packing rate, 120 cwt./hr.; annual volume, 96,000 cwt.					Packing rate, 240 cwt./hr.; annual volume, 192,000 cwt.				
								Operating cost			Total annual cost	Cost per cwt.	Operating cost			Total annual cost	Cost per cwt.
				Depreciation	Interest @ 5%	Ins. & taxes @ 4%	Total	Power	Maintenance	Total			Power	Maintenance	Total		
	No.	Dol.	Yr.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.
Flat-belt conveyor	1	441.00	15	29.40	11.03	17.64	58.07	5.97	52.92	58.89	116.96	0.0012	5.97	52.92	58.89	116.96	0.0006
Flat-belt conveyor to elevator	1	512.00	15	34.13	12.80	20.48	67.41	5.97	61.44	67.41	134.82	.0014	5.97	61.44	67.41	134.82	.0007
Bulk bucket elevator	1	1,185.38	15	79.03	29.63	47.42	156.08	17.90	142.25	160.15	316.23	.0033	17.90	142.25	160.15	316.23	.0016
Sack elevator	1	1,100.00	15	73.33	27.50	44.00	144.83	--	--	--	144.83	.0015	--	--	--	144.83	.0007
Flat-belt extending conveyor	1	2,218.00	15	147.87	55.45	88.72	292.04	14.03	256.25	270.28	562.32	.0058	16.12	256.42	272.54	564.58	.0030
Total		5,456.38		363.76	136.41	218.26	718.43	43.87	512.86	556.73	1,275.16	.0132	45.96	513.04	558.99	1,277.42	.0066

Table 8.--Packing plant, method C: Equipment ownership and operating costs for 100 days of operation at two packing rates and two annual volumes

Item	Units	Initial cost	Exp. life	Ownership cost				Packing rate, 120 cwt./hr.; annual volume, 96,000 cwt.					Packing rate, 240 cwt./hr.; annual volume, 192,000 cwt.				
								Operating cost			Total annual cost	Cost per cwt.	Operating cost			Total annual cost	Cost per cwt.
				Depreciation	Interest @ 5%	Ins. & taxes @ 4%	Total	Power	Maintenance	Total			Power	Maintenance	Total		
	No.	Dol.	Yr.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.
Flat-belt conveyor	1	1,350.00	15	90.00	33.75	54.00	177.75	11.94	162.00	173.94	351.69	0.0036	11.94	162.00	173.94	351.69	0.0018
Bulk hopper bin	2	2,900.00	25	116.00	72.50	116.00	304.50	--	20.00	20.00	324.50	.0034	--	20.00	20.00	324.50	.0017
Belt conveyor in bin	2	1,376.00	15	91.73	34.40	55.04	181.17	3.20	14.72	17.92	199.09	.0021	6.40	29.44	35.84	217.01	.0012
Bucket elevator on track	1	1,591.68	15	106.11	39.79	63.67	209.57	17.90	191.00	208.90	418.47	.0044	17.90	191.00	208.90	418.47	.0022
Overhead bin-filling conveyor	1	1,146.00	15	76.40	28.65	45.84	150.89	8.96	137.52	146.48	297.37	.0031	8.96	137.52	146.48	297.37	.0015
Cleated-belt elevating conveyor	1	1,191.80	15	79.45	29.80	47.67	156.92	4.27	25.56	29.83	186.75	.0019	8.54	51.12	59.66	216.58	.0011
Telescoping conveyor	1	2,359.00	15	157.27	58.98	94.36	310.61	4.27	50.48	54.75	365.36	.0038	8.54	100.96	109.50	420.11	.0022
Total		11,914.48		716.96	297.87	476.58	1,491.41	50.54	601.28	651.82	2,143.23	.0223	62.28	692.04	754.32	2,245.73	.0117

Table 9.--Packing plant, method D: Equipment ownership and operating costs for 100 days of operation at two packing rates and two annual volumes

Item	Units	Initial cost	Exp. life	Ownership cost				Packing rate, 120 cwt./hr.; annual volume, 96,000 cwt.					Packing rate, 240 cwt./hr.; annual volume, 192,000 cwt.				
								Operating cost			Total annual cost	Cost per cwt.	Operating cost			Total annual cost	Cost per cwt.
				Depreciation	Interest @ 5%	Ins. & taxes @ 4%	Total	Power	Maintenance	Total			Power	Maintenance	Total		
	No.	Dol.	Yr.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.
Flat-belt conveyor	1	1,350.00	15	90.00	33.75	54.00	177.75	11.94	162.00	173.94	351.69	0.0036	11.94	162.00	173.94	351.69	0.0018
Bulk hopper bins	2	2,900.00	25	116.00	72.50	116.00	304.50	--	20.00	20.00	324.50	.0034	--	20.00	20.00	324.50	.0017
Belt conveyor in bin	2	1,376.00	15	91.73	34.40	55.04	181.17	3.20	14.72	17.92	199.09	.0021	6.40	29.44	35.84	217.01	.0012
Bucket elevator on track	1	1,591.68	15	106.11	39.79	63.67	209.57	17.90	191.00	208.90	418.47	.0044	17.90	191.00	208.90	418.47	.0022
Overhead bin-filling conveyor	1	1,146.00	15	76.40	28.65	45.84	150.89	8.96	137.52	146.48	297.37	.0031	8.96	137.52	146.48	297.37	.0015
Flat-belt conveyor to elevator	1	536.00	15	35.73	13.40	21.44	70.57	1.60	11.50	13.10	83.67	.0009	3.20	23.00	26.20	96.77	.0005
Bucket elevator	1	1,267.11	15	84.47	31.68	50.68	166.83	4.27	27.18	31.45	198.28	.0020	8.54	54.36	62.90	229.73	.0012
Sack elevator	1	1,100.00	15	73.33	27.50	44.00	144.83	--	--	--	144.83	.0015	--	--	--	144.83	.0007
Flat-belt extending conveyor	1	2,233.00	15	148.87	55.83	89.32	294.02	5.29	46.26	51.55	345.57	.0036	10.58	92.52	103.10	397.12	.0021
Total		13,499.79		822.64	337.50	539.99	1,700.13	53.16	610.18	663.34	2,363.47	.0246	67.52	709.84	777.36	2,477.49	.0129

Table 10.--Packing plant, method E: Equipment ownership and operating costs for 100 days of operation at two packing rates and two annual volumes

Item	Units	Initial cost	Exp. life	Ownership cost				Packing rate, 120 cwt./hr.; annual volume, 96,000 cwt.					Packing rate, 240 cwt./hr.; annual volume, 192,000 cwt.				
								Operating cost			Total annual cost	Cost per cwt.	Operating cost			Total annual cost	Cost per cwt.
				Depreciation	Interest @ 5%	Ins. & taxes @ 4%	Total	Power	Maintenance	Total			Power	Maintenance	Total		
	No.	Dol.	Yr.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.
Flat-belt conveyor	1	1,570.00	15	104.67	39.25	62.80	206.72	17.90	188.40	206.30	413.02	0.0043	17.90	188.40	206.30	413.02	0.0022
Bulk hopper bins	3	4,350.00	25	174.00	108.75	174.00	456.75	--	30.00	30.00	486.75	.0051	--	30.00	30.00	486.75	.0025
Belt conveyor in bin	3	2,064.00	15	137.60	51.60	82.56	271.76	3.20	14.72	17.92	289.68	.0030	6.40	29.44	35.84	307.60	.0016
Bucket elevator on track	1	1,616.68	15	107.78	40.42	64.67	212.87	17.90	194.00	211.90	424.77	.0044	17.90	194.00	211.90	424.77	.0022
Overhead bin-filling conveyor	1	1,172.50	15	78.17	29.31	46.90	154.38	8.96	140.70	149.66	304.04	.0032	8.96	140.70	149.66	304.04	.0016
Cleated-belt elevating conveyor	1	1,191.80	15	79.45	29.80	47.67	156.92	4.27	25.56	29.83	186.75	.0019	8.54	51.12	59.66	216.58	.0011
Telescoping conveyor	1	2,359.00	15	157.27	58.98	94.36	310.61	4.27	50.48	54.75	365.36	.0038	8.54	100.96	109.50	420.11	.0022
Total		14,323.98		838.94	358.11	572.96	1,770.01	56.50	643.86	700.36	2,470.37	.0257	68.24	734.62	802.86	2,572.67	.0134

Table 11.--Packing plant, method F: Equipment ownership and operating costs for 100 days of operation at two packing rates and two annual volumes

Item	Units	Initial cost	Exp. life	Ownership cost				Packing rate, 120 cwt./hr.; annual volume, 96,000 cwt.					Packing rate, 240 cwt./hr.; annual volume, 192,000 cwt.				
								Operating cost					Operating cost				
				Depreciation	Interest @ 5%	Ins. & taxes @ 4%	Total	Power	Maintenance	Total	Total annual cost	Cost per cwt.	Power	Maintenance	Total	Total annual cost	Cost per cwt.
	No.	Dol.	Yr.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.
Flat-belt conveyor	1	1,570.00	15	104.67	39.25	62.80	206.72	17.90	188.40	206.30	413.02	0.0043	17.90	188.40	206.30	413.02	0.0022
Bulk hopper bins	3	4,350.00	25	174.00	108.75	174.00	456.75	--	30.00	30.00	486.75	.0051	--	30.00	30.00	486.75	.0025
Belt conveyor in bins	3	2,064.00	15	137.60	51.60	82.56	271.76	3.20	14.72	17.92	289.68	.0030	6.40	29.44	35.84	307.60	.0016
Bulk bucket elevator on track	1	1,616.68	15	107.78	40.42	64.67	212.87	17.90	194.00	211.90	424.77	.0044	17.90	194.00	211.90	424.77	.0022
Overhead bin-filling conveyor	1	1,172.50	15	78.17	29.31	46.90	154.38	8.96	140.70	149.66	304.04	.0032	8.96	140.70	149.66	304.04	.0016
Flat-belt conveyor to elevator	1	536.00	15	35.73	13.40	21.44	70.57	1.60	11.50	13.10	83.67	.0008	3.20	23.00	26.20	96.77	.0005
Bulk bucket elevator	1	1,267.11	15	84.47	31.68	50.68	166.83	4.27	27.18	31.45	198.28	.0021	8.54	54.36	62.90	229.73	.0012
Sack elevator	1	1,100.00	15	73.33	27.50	44.00	144.83	--	--	--	144.83	.0015	--	--	--	144.83	.0007
Flat-belt extending conveyor	1	2,233.00	15	148.87	55.83	89.32	294.02	5.29	46.26	51.55	345.57	.0036	10.58	92.52	103.10	397.12	.0021
Total		15,909.29		944.62	397.74	636.37	1,978.73	59.12	652.76	711.88	2,690.61	.0280	73.48	752.42	825.90	2,804.63	.0146

Table 12.--Transportation company: Ownership and operating costs for equipment used to haul an annual volume of 96,000 cwt. of potatoes 700 miles in 240 truckloads, from a packing plant packing at a rate of 120 cwt. per hour for 100 days of operation

Item	Units	Initial cost	Exp. life	Ownership cost				Operating cost			Total annual cost	Cost per cwt.
				Depreciation	Interest @ 5%	Ins. & taxes @ 4%	Total	Power	Maintenance	Total		
	No.	Dol.	Yr.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.
Methods A and B												
Bulk bins	10	2,500.00	10	250.00	62.50	100.00	412.50	--	24.00	24.00	1/ 182.81	0.0019
Bulk bin conveyor	10	2,100.00	10	210.00	52.50	84.00	346.50	--	10.35	10.35	1/ 143.75	.0015
Total		4,600.00		460.00	115.00	184.00	759.00	--	34.35	34.35	326.56	.0034
Methods C-D-E-F												
Bulk bin	9	2,250.00	10	225.00	56.25	90.00	371.25	--	24.00	24.00	1/ 166.93	.0017
Bulk bin conveyor	9	1,890.00	10	189.00	47.25	75.60	311.85	--	10.35	10.35	1/ 130.41	.0014
Total		4,140.00		414.00	103.50	165.60	683.10	--	34.35	34.35	297.34	.0031

1/ 61.5 percent of ownership costs was allocated to transporting from other plants for 160 days of operation.

Table 13.--Transportation company: Ownership and operating costs for equipment used to haul an annual volume of 192,000 cwt. of potatoes 700 miles in 480 truckloads, from a packing plant packing at a rate of 240 cwt. per hour for 100 days of operation

Item	Units	Initial cost	Exp. life	Ownership costs				Operating cost			Total annual cost	Cost per cwt.
				Depreciation	Interest @ 5%	Ins. & taxes @ 4%	Total	Power	Maintenance	Total		
	No.	Dol.	Yr.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.
Methods A and B												
Bulk bins	20	5,000.00	10	500.00	125.00	200.00	825.00	--	48.00	48.00	1/ 365.63	0.0019
Bulk bin conveyor	20	4,200.00	10	420.00	105.00	168.00	693.00	--	20.70	20.70	1/ 287.50	.0015
Total		9,200.00		920.00	230.00	368.00	1,518.00	--	68.70	68.70	653.13	.0034
Methods C-D-E-F												
Bulk bins	19	4,750.00	10	475.00	118.75	190.00	783.75	--	48.00	48.00	1/ 349.74	.0018
Bulk bin conveyor	19	3,990.00	10	399.00	99.75	159.60	658.35	--	20.70	20.70	1/ 274.16	.0014
Total		8,740.00		874.00	218.50	349.60	1,442.10	--	68.70	68.70	623.90	.0032

1/ 61.5 percent of ownership costs allocated to transporting from other plants for 160 days of operation.

Table 14.--Processing plant: Equipment ownership and operating costs when processing 60 cwt. of potatoes per hour 960 cwt. per day, annual volume of 249,600 cwt. for 260 days of operation

Item	Units	Initial cost	Exp. life	Ownership cost				Operating cost			Total annual cost	Cost per cwt.
				Depreciation	Interest @ 5%	Ins. & taxes @ 4%	Total	Power	Maintenance	Total		
	No.	Dol.	Yr.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.	Dol.
Pallet boxes	320	3,696.30	10	369.60	92.33	147.77	609.70	--	269.50	269.50	879.20	0.0035
Box tippers, chip lines	2	1,322.00	15	88.13	33.05	52.88	174.06	9.31	22.74	32.05	206.11	.0008
Box tipper, receiving	1	964.00	15	64.27	24.10	38.56	126.93	33.52	103.82	137.34	264.27	.0011
Roller conveyors--sections	3	424.00	15	28.27	10.60	16.96	55.83	--	55.12	55.12	110.95	.0004
Conveyor, cleated belt, 14'	1	578.00	10	57.80	14.45	23.12	95.37	7.88	61.03	68.91	164.28	.0007
Forklift truck, 3,000-lb. cap	1	5,355.00	7	765.00	133.88	214.20	1,113.08	275.50	197.25	472.75	1,585.83	.0064
Motor and gear reducer for truck conveyor	1	184.00	15	12.27	4.60	7.36	24.23	15.76	19.43	35.19	59.42	.0002
Total		12,523.00		1,385.34	313.01	500.85	2,199.20	341.97	728.89	1,070.86	3,270.06	.0131

Table 15.--Computation of annual space costs for potato packinghouse, using six methods, and for processor

Location and method	Building dimensions			Est. cost of building 1/	Annual costs				
	Length	Width	Height		Depreciation 2/	Interest at 5 percent of avg. cost	Ins. and taxes at 3 percent	Maintenance at 0.5 percent	Total
	Feet	Feet	Feet	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
Packinghouse:									
Method A	40	26	14	4,455	178.20	111.38	133.65	22.28	445.51
" B	40	24	14	4,227	169.06	105.67	126.81	21.13	422.67
" C	54	32	16	7,023	280.92	175.58	210.69	35.12	702.31
" D	42	42	16	7,238	289.52	180.95	217.14	36.19	723.80
" E	62	32	16	7,824	312.96	195.60	234.72	39.12	782.40
" F	50	42	16	8,112	324.48	202.80	243.36	40.56	811.20
Processor:									
All methods	100	40	16	3/ 32,010	1,280.40	800.25	960.30	160.05	3,201.00

1/ Based on an assumed cost of construction of $1 per square foot for floors, walls and roof. All roofs were 1/4 pitch. An allowance was made for trusses and posts.

2/ An expected life of 25 years was assumed.

3/ Since the processor's building would be in a metropolitan area, the cost per cubic foot of space was assumed to be double that for the packinghouse.

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